

We claim:

1. A treatment of waste process for using mediated electrochemical oxidation (MEO) for the oxidation, conversion/recovery, and decontamination (such as cleaning equipment and containers, etc.) of all previously defined inorganic solid, liquid, or gas where higher oxidation states exist which includes, but is not limited to, halogenated inorganic compounds (except fluorinated), inorganic pesticides and herbicides, inorganic fertilizers, carbon residues, incinerator residue, inorganic carbon compounds, mineral formations, mining tailings, inorganic salts, metals and metal compounds, etc.; and combined waste (e.g. a mixture of any of the foregoing with each other or other non-inorganic materials) further comprising disposing an electrolyte in an electrochemical cell, separating the electrolyte into an anolyte portion and a catholyte portion with an ion-selective membrane or semi-permeable membrane, applying a direct current voltage between the anolyte portion and the catholyte portion, placing the waste and/or inorganic materials in the anolyte portion, and oxidizing the waste and/or inorganic materials in the anolyte portion with the mediated electrochemical oxidation (MEO) process, wherein the anolyte portion further comprises a mediator or mediators (oxidizing species) in aqueous solution and containing acid, neutral or alkaline electrolytes.

2. The process of claim 1, wherein the mediator (oxidizing species) is selected from the group of mediators described in Table I.

3. The process of claim 1, wherein the mediator oxidizing species are selected from one or more of a group of Type I complex anion redox couple isopolyanion mediators containing tungsten, molybdenum, vanadium, niobium, tantalum, or combinations thereof as addenda atoms in aqueous solution.

4. The process of claim 1, wherein the mediator oxidizing species are selected from one or more of a group of Type I heteropolyanions formed by incorporation into Type I isopolyanions, as heteroatoms, any of the elements listed in Table II, either singly or in combination thereof in the aqueous solution.

5. The process of claim 1, wherein the mediator oxidizing species are selected from one or more of a group of heteropolyanions containing at least one heteroatom type element contained in both Table I and Table II in the aqueous solution.

6. The process of claim 1, wherein the mediator oxidizing species are selected from a group of combinations of anion redox couple mediators described in Tables I and II, and wherein reduced forms of the redox couples are reoxidized in the anolyte portion within the electrochemical cell.

7. The process of claim 1, further comprising introducing catalyst additives to the electrolyte and thereby increasing the kinetics of the mediated electrochemical processes while keeping the additives from becoming directly involved in the oxidizing of waste and/or inorganic materials.

8. The process of claim 1, further comprising adding stabilizing compounds to the electrolyte for overcoming and stabilizing the short lifetime of oxidized forms of higher oxidation state species of the mediator oxidizing species.

9. The process of claim 1, wherein the mediator oxidizing species are identified in Table I, and wherein each of the species has normal valence states and higher valence oxidizing states and further comprising creating the higher valence oxidizing states of the mediator oxidizing species by stripping electrons from normal valence state species in the electrochemical cell.

10. The process of claim 1, wherein the mediator oxidizing species are super oxidizers which exhibit oxidation potentials of at least 1.7 volts at 1 molar, 25°C and pH 1 and which are redox couple species that have the capability of producing free radicals of hydroxyl or perhydroxyl, and further comprising creating free radical secondary oxidizers by reacting the super oxidizers with water.

11. The process of claim 1, further comprising using an alkaline solution, aiding decomposing of the biological materials in waste and/or inorganic materials derived from base promoted ester hydrolysis, saponification of fatty acids, and forming water soluble alkali metal salts of the fatty acids and glycerin in a process similar to the production of soap from animal fat by introducing it into a hot aqueous lye solution.

12. The process of claim 1, further comprising using an alkaline anolyte solution for absorbing CO<sub>2</sub> from the oxidizing of waste and/or inorganic materials and forming bicarbonate/carbonate solutions, which

subsequently circulate through the electrochemical cell, producing percarbonate oxidizers.

13. The process of claim 1, wherein the mediator oxidizing agents species are super oxidizers, and further comprising generating inorganic free radicals in aqueous solutions from carbonate, azide, nitrite, nitrate, phosphite, phosphate, sulfite, sulfate, selenite, thiocyanate, chloride, bromide, iodide, and formate oxidizing species.

14. The process of claim 1, wherein the membrane is microporous plastic, ion-selective, porous ceramic or sintered glass frit.

15. The process of claim 1, further comprising impressing an AC voltage upon the direct current voltage for retarding formation of cell performance limiting surface films on the electrodes or the membrane.

16. The process of claim 1, further comprising disposing a foraminous basket in the anolyte and holding the waste and/or inorganic materials in the basket.

17. The process of claim 1, wherein the catholyte portion contains  $\text{HNO}_3$  or  $\text{NO}_3^-$  salts, and further comprising adding oxygen to the catholyte portion to suppress the formation of  $\text{NO}_x$ .

18. The process of claim 1, wherein the mediator oxidizing species is simple anions described in Table I, Type I isopolyanions containing tungsten, molybdenum, vanadium, niobium, tantalum, or combinations thereof as addenda atoms; Type I heteropolyanions formed by incorporation into the aforementioned isopolyanions, as heteroatoms, any of the elements listed in Table II, either singly or in combinations thereof; or any heteropolyanions containing at least one heteroatom type contained in both Table I and Table II.

19. The process of claim 1, further comprising adjusting a temperature between  $0^\circ\text{C}$  and slightly below the boiling point of the anolyte portion before it enters the electrochemical cell for enhancing generation of oxidized forms of the mediator oxidizing species, and adjusting the temperature between  $0^\circ\text{C}$  and below the boiling temperature of the anolyte portion entering the anolyte reaction chamber affecting desired chemical reactions at desired rates.

20. The process of claim 1, further comprising introducing an ultrasonic energy into the anolyte portion, rupturing cell membranes in the biological materials in waste and/or inorganic materials by

momentarily raising local temperature and pressure within the cell membranes with the ultrasonic energy to above several thousand degrees and thousand atmospheres, and causing cell membrane failure.

21. The process of claim 1, further comprising inorganic waste containing elements that are identified in Table I as anion redox couples, which become possible mediated redox couples when the oxidation of the inorganic waste releases them into solution as the reduced form of the redox couple and are raised to the oxidized form when they pass through the electrochemical cell.

22. The process of claim 1, further comprising introducing ultraviolet energy into the anolyte portion and decomposing hydrogen peroxide into hydroxyl free radicals therein, thereby increasing efficiency of the process by converting products of electron consuming parasitic reactions, ozone and hydrogen peroxide, into viable free radical secondary oxidizers without consumption of additional electrons.

23. The process of claim 1, further comprising adding a surfactant to the anolyte portion for promoting dispersion of the waste and/or inorganic materials or intermediate stage reaction products within the aqueous solution when the waste and/or inorganic materials or reaction products are not water-soluble and tend to form immiscible layers.

24. The process of claim 1, further comprising attacking specific organic molecules in the waste and/or inorganic materials with the mediator oxidizing species while operating at sufficiently low temperatures and preventing formation of dioxins and furans.

25. The process of claim 1, further comprising breaking down the waste and/or inorganic materials into biological and organic compounds and attacking these compounds using as the mediator simple and/or complex anion redox couple mediators or inorganic free radicals and generating organic free radicals.

26. The process of claim 1, further comprising raising normal valence state mediator anions to a higher valence state by stripping the mediator anions of electrons in the electrochemical cell, wherein oxidized forms of weaker redox couples present in the mediator oxidizing species are produced by similar anodic oxidation or reaction with oxidized forms of stronger redox couples present and the oxidized species of the redox couples oxidize molecules of the waste and/or inorganic materials and are

themselves converted to their reduced form, whereupon they are oxidized by the aforementioned mechanisms and the redox cycle continues.

27. A process for treating waste comprising oxidizing waste and/or inorganic materials, comprising circulating anions of mediator oxidizing species in an electrolyte through an electrochemical cell and affecting anodic oxidation of reduced forms of reversible redox couples into oxidized forms, contacting the anions with the waste and/or inorganic materials in an anolyte portion of the electrolyte in a primary oxidation process, involving super oxidizer anions, having an oxidation potential above a threshold value of 1.7 volts at 1 molar, 25°C and pH1 thereby creating a free radical oxidizer driven secondary oxidation process, adding energy from an energy source to the anolyte portion and augmenting the secondary oxidation processes, breaking down hydrogen peroxide in the anolyte portion into hydroxyl free radicals, and increasing an oxidizing effect of the secondary oxidation processes.

28. The process of claim 27, wherein the adding energy comprises irradiating the anolyte portion with ultraviolet energy.

29. The process of claim 27, wherein the adding energy comprises introducing an ultrasonic energy source into the anolyte portion, irradiating cell membranes in the waste and/or inorganic materials, momentarily raising local temperature within the cell membranes, causing failure of the cell membranes, and creating greater exposure of cell contents in the waste and/or inorganic materials to oxidizing species in the anolyte portion.

30. The process of claim 27, wherein the adding energy comprises introducing an ultrasonic energy source and/or an ultraviolet energy source into the anolyte portion, promoting the formation of the hydroxyl free radicals.

31. The process of claim 27, wherein the mediator oxidizing species are simple anions redox couple mediators described in Table I; Type I isopolyanions formed by Mo, W, V, Nb, Ta, or mixtures thereof; Type I heteropolyanions formed by incorporation into the isopolyanions if any of the elements listed in Table II (heteroatoms) either singly or in combination thereof, or heteropolyanions containing at least one heteroatom type element contained in both Table I and Table II or

combinations of the mediator oxidizing species from any or all of these generic groups.

32. The process of claim 27, further comprising using the mediator oxidizing species that are found in situ in the waste and/or inorganic materials to be decomposed, by circulating the waste and/or inorganic materials-anolyte mixture through the electrochemical cell wherein an oxidized form of an insitu reversible redox couple is formed by anodic oxidizing or reacting with an oxidized form of a more powerful redox couple added to or already present in the anolyte portion and anodically oxidized in the electrochemical cell, thereby destroying the biological and organic materials in the waste and/or inorganic materials.

33. The process of claim 27, further comprising using an alkaline electrolyte selected from a group consisting of NaOH or KOH and combinations thereof, with the mediator oxidizing species, wherein a reduced form of a mediator redox couple has sufficient solubility in said electrolyte for allowing desired oxidation of the biological and organic materials in the waste and/or inorganic materials.

34. The process of claim 27, wherein the oxidation potential of redox reactions of the mediator oxidizing species and the biological and organic molecules in the waste and/or inorganic materials producing hydrogen ions are inversely proportional to electrolyte pH, and wherein a selection of a mediator redox couple increasing the electrolyte pH reduces the electric potential required, thereby reducing electric power consumed per unit mass of the waste and/or inorganic materials destroyed.

35. The process of claim 27, wherein the electrolyte is an aqueous solution chosen from acids, alkalines and neutral electrolytes and mixtures thereof.

36. The process of claim 27, wherein the added energy comprises using ultrasonic energy and inducing microscopic bubble expansion and implosion for reducing in size individual second phase waste and/or inorganic materials volumes dispersed in the anolyte.

37. The process of claim 27, further comprising interchanging the mediator oxidizing species without changing equipment, and wherein the electrolyte is an acid, neutral or alkaline aqueous solution.

38. The process of claim 27, further comprising separating the anolyte portion and a catholyte portion of the electrolyte with a hydrogen

or hydronium ion-permeable membrane, microporous polymer, porous ceramic or glass frit membrane.

39. The process of claim 27, further comprising electrically energizing the electrochemical cell at a potential level sufficient for forming the oxidized forms of redox couples having highest oxidizing potential in the anolyte, introducing the waste and/or inorganic materials into the anolyte portion, forming reduced forms of one or more reversible redox couples by contacting with oxidizable molecules, the reaction reacting with which and oxidizing the oxidizable material with the concomitant reduction of the oxidized forms of the reversible redox couples to their reduced forms, and wherein the adding energy comprises providing an ultrasonic source connected to the anolyte portion for augmenting secondary oxidation oxidizing processes by momentarily heating the hydrogen peroxide in the electrolyte to 4800°C at 1000 atmospheres thereby dissociating the hydrogen peroxide into hydroxyl free radicals thus increasing the oxidizing processes.

40. The process of claim 39, wherein oxidation potentials of redox reactions producing hydrogen ions are inversely related to pH.

41. The process of claim 27, wherein the process is performed at a temperature from slightly above 0°C to slightly below the boiling point of the electrolyte.

42. The process of claim 41, wherein the temperature at which the process is performed is varied.

43. The process of claim 27, wherein the oxidizing and destroying waste and/or inorganic materials comprises destroying and oxidizing solid waste and/or inorganic materials.

44. The process of claim 27, wherein the oxidizing and destroying waste and/or inorganic materials comprises oxidizing and destroying liquid waste and/or inorganic materials.

45. The process of claim 27, wherein the treating and oxidizing waste and/or inorganic materials comprises treating and oxidizing gas waste and/or inorganic materials;

46. The process of claim 27, wherein the oxidizing and destroying waste and/or inorganic materials comprises oxidizing and destroying a combination of liquids, solids, and gases in waste and/or inorganic materials.

47. The process of claim 27, further comprising removing and treating precipitates resulting from combinations of the oxidizing species and other species released from the waste and/or inorganic materials during destruction and sterilization.

48. The process of claim 27, further comprising a catholyte portion of the electrolyte, and wherein the anolyte and catholyte portions of electrolyte are independent of one another, and comprise aqueous solutions of acids, alkali or neutral salt.

49. The process of claim 27, further comprising separating a catholyte portion of the electrolyte from the anolyte portion with a membrane, operating the electrochemical cell at a higher current density across the membrane, and near a limit over which there is the possibility that metallic anions may leak through the membrane in small quantities, and recovering the metallic anions through a resin column, thus allowing a greater rate of destruction of waste and/or inorganic materials in the anolyte portion.

50. The process of claim 27, wherein the catholyte solution portion further comprises an aqueous solution and the electrolyte in the solution is composed of acids, alkali or neutral, and further comprising adding oxygen to the solution when  $\text{HNO}_3$  or  $\text{NO}_3^-$  occurs in the catholyte portion, controlling concentration of electrolyte in the catholyte to maintain conductivity of the catholyte portion desired in the electrochemical cell, providing mechanical mixing and/or ultrasonic energy induced microscopic bubble formation, and implosion for vigorous mixing in the catholyte solution for oxidizing the nitrous acid and small amounts of nitrogen oxides  $\text{NO}_x$ , introducing air into the catholyte portion for promoting the oxidizing of the nitrous acid and the small amounts of  $\text{NO}_x$ , and diluting any hydrogen produced in the catholyte portion before releasing the air and hydrogen.

51. Apparatus for the use of mediated electrochemical oxidation (MEO) for the oxidation, conversion/recovery, and decontamination (such as cleaning equipment and containers, etc.) of all previously defined inorganic solid, liquid, or gas where higher oxidation states exist which includes, but is not limited to, halogenated inorganic compounds (except fluorinated), inorganic pesticides and herbicides, inorganic fertilizers, carbon residues, incinerator residue, inorganic carbon compounds, mineral



formations, mining tailings, inorganic salts, metals and metal compounds, etc.; and combined waste (e.g. a mixture of any of the foregoing with each other or other non-inorganic materials) further comprising an electrochemical cell, an aqueous electrolyte disposed in the electrochemical cell, a hydrogen or hydronium ion-permeable or selective membrane disposed in the electrochemical cell for separating the cell into anolyte and catholyte chambers and separating the electrolyte into aqueous anolyte and catholyte portions, electrodes further comprising an anode and a cathode disposed in the electrochemical cell respectively in the anolyte and catholyte chambers and in the anolyte and catholyte portions of the electrolyte, a power supply connected to the anode and the cathode for applying a direct current voltage between the anolyte and the catholyte portions of the electrolyte, and oxidizing of the materials in the anolyte portion with a mediated electrochemical oxidation (MEO) process wherein the anolyte portion further comprises a mediator in aqueous solution for producing reversible redox couples used as oxidizing species and wherein the electrolyte is an acid, neutral or alkaline aqueous solution.

52. The apparatus of claim 51, further comprising an anolyte reaction chamber and buffer tank housing the bulk of the anolyte solution, an input pump to enter liquid waste and/or inorganic materials into the anolyte reaction chamber, a spray head and stream head to introduce the anolyte from the electrochemical cell into the anolyte reaction chamber in such a manner as to promote mixing of the incoming anolyte and the anolyte mixture in the anolyte reaction chamber, a hinged lid to allow insertion of waste and/or inorganic materials into the anolyte portion as liquid, solid or combination of both, a locking latch to secure the lid during operation of the system, a suction pump attached to the buffer tank to pump anolyte from the buffer tank to the anolyte reaction chamber, a input pump to pump anolyte from the anolyte reaction chamber back to the buffer tank, and an air pump to pump off gases from the anolyte reaction chamber back to the buffer tank for further oxidation.

53. The apparatus of claim 51, further comprising a foraminous basket disposed in the anolyte chamber for receiving the solid waste and/or inorganic materials.

54. The apparatus of claim 51, further comprising additives disposed in the electrolyte for contributing to kinetics of the mediated electrochemical processes while keeping it from becoming directly involved in the oxidizing of the waste and/or inorganic materials, and stabilizer compounds disposed in the electrolyte for stabilizing higher oxidation state species of oxidized forms of the reversible redox couples used as the mediator oxidizing species in the electrolyte.

55. The apparatus of claim 51, wherein the mediator oxidizer species are simple anions redox couple mediators described in Table I: Type I isopolyanions formed by Mo, W, V, Nb, Ta, or mixtures thereof, Type I heteropolyanions formed by incorporation into the isopolyanions in heteroatom elements listed in Table II, or any heteropolyanions containing at least one heteroatom type element contained in both Table I and Table II or combinations of mediator species from any or all of these generic groups.

56. The apparatus of claim 51, wherein the mediator oxidizing species are super oxidizers and further comprising creating secondary oxidizers disposed in the anolyte portion by reacting with the super oxidizers in the aqueous anolyte.

57. The apparatus of claim 51, wherein the anolyte portion comprises an alkaline solution for aiding in the decomposing of the materials, for absorbing CO<sub>2</sub>, for forming alkali metal bicarbonate/carbonate for circulating through the electrochemical cell, and for producing a percarbonate oxidizer.

58. The apparatus of claim 51, wherein the anolyte portion further comprises super oxidizers generating inorganic free radicals in aqueous solutions derived from carbonate, azide, nitrite, nitrate, phosphite, phosphate, sulfite, sulfate, selenite, thiocyanate, chloride, bromide, and iodide species, anions with an oxidation potential above a threshold value of 1.7 volts at 1 molar, 25°C and pH1 (i.e., super oxidizer) for involving in a secondary oxidation process for producing oxidizers, and organic free radicals for aiding the process and breaking down the waste and/or inorganic materials into simpler smaller molecular structure biological and organic compounds.

59. The apparatus of claim 51, further comprising an ultrasonic energy source within or near the anolyte chamber for producing microscopic

bubbles and implosions for reducing in size individual second phase waste and/or inorganic materials volumes dispersed in the anolyte.

60. The apparatus of claim 51, wherein the membrane is made of microporous polymer, porous ceramic or glass frit.

61. The apparatus of claim 51, further comprising an AC source for impression of an AC voltage upon the DC voltage to retard the formation of cell performance limiting surface films on the electrodes and/or membranes.

62. The apparatus of claim 51, further comprising an air sparge connected to the catholyte reservoir, whereby oxygen contained in the air oxidizes nitrous acid and the small amounts of nitrogen oxides ( $\text{NO}_x$ ), produced by cathode reactions when  $\text{HNO}_3$  or  $\text{NO}_3^-$  salts are present in the catholyte.

63. The apparatus of claim 51, wherein each of the mediator oxidizing species has normal valence states in reduced forms of redox couples and higher valence oxidizing states in oxidized forms of redox couples of the mediator oxidizing species created by stripping and reducing electrons off normal valence state species in the electrochemical cell.

64. The apparatus of claim 51, wherein the anolyte portions are alkaline solutions and oxidation potentials of redox reactions producing hydrogen ions are inversely related to pH, which reduces the electrical power required to oxidize and destroy the waste and/or inorganic materials.

65. The apparatus of claim 51, wherein the mediator oxidizing species attack specific organic molecules in the waste and/or inorganic materials while operating at temperatures sufficiently low so as to prevent the formation of dioxins and furans.

66. The apparatus of claim 51, wherein the power supply energizes the electrochemical cell at a potential level sufficient to form the oxidized form of the redox couple having the highest oxidation potential in the anolyte, and further comprising a heat exchanger connected to the anolyte chamber for controlling temperature between  $0^\circ\text{C}$  and slightly below the boiling temperature of the anolyte with the heat exchanger before the anolyte enters the electrochemical cell enhancing the generation of oxidized forms of the anion redox couple mediator, and adjusting the

temperature of the anolyte to the range between 0°C and slightly below the boiling temperature when entering the anolyte reaction chamber.

67. The apparatus of claim 51, wherein the mediator oxidizing species are one or more Type I isopolyanion complex anion redox couple mediators containing tungsten, molybdenum, vanadium, niobium, tantalum, or combinations thereof as addenda atoms in aqueous solution.

68. The apparatus of claim 67, wherein the mediator oxidizing species are one or more Type I heteropolyanions formed by incorporation into the isopolyanions, as heteroatoms, of the elements listed in Table II, either singly or in combination thereof.

69. The apparatus of claim 51, wherein the mediator oxidizing species are one or more heteropolyanions containing at least one heteroatom type element contained in Table I and Table II.

70. The apparatus of claim 51, wherein the mediator oxidizing species are higher valence state of species found in situ for destroying of waste and/or inorganic materials.

71. The apparatus of claim 51, wherein the membrane is hydrogen or hydronium ion semi-permeable or ion-selective, microporous polymer, porous ceramic or glass frit membrane for separating the anolyte portion and the catholyte portion while allowing hydrogen or hydronium ion passage from the anolyte to the catholyte.

72. The apparatus of claim 51, wherein oxidation potentials of redox reactions producing hydrogen ions are inversely related to pH, the waste and/or inorganic materials is liquid, solid, and gas or a combination of liquids, solids, and gas and the oxidizing species are interchangeable without changing other elements of the apparatus.

73. The apparatus of claim 51, further comprising an ultraviolet source connected to the anolyte chamber for decomposing hydrogen peroxide into hydroxyl free radicals as secondary oxidizers and increasing efficiency of the process by recovering energy through the oxidation of the waste and/or inorganic materials in the anolyte chamber by the secondary oxidizers.

74. The apparatus of claim 51, further comprising an ultrasonic source connected to the anolyte for augmenting secondary oxidation processes by heating hydrogen peroxide containing electrolyte to 4800°C, at 1000 atmospheres for dissociating hydrogen peroxide into hydroxyl free

radicals and thus increasing concentration of oxidizing species and rate of waste destruction and for irradiating cell membranes in biological materials in the waste and/or inorganic materials to momentarily raise the temperature within the cell membranes to above several thousand degrees, causing failure of the cell membranes, and creating greater exposure of cell contents to oxidizing species in the anolyte.

75. The apparatus of claim 51, further comprising use of ultrasonic energy, via the ultrasonic energy source communicating with the anolyte for inducing microscopic bubble implosions to affect a reduction in size of the individual second phase waste volumes dispersed in the anolyte.

76. The apparatus of claim 51, further comprising an anolyte reaction chamber holding most of the anolyte portion and a foraminous basket, a penetrator attached to the basket to puncture solids increasing the exposed area, and further comprising an external CO<sub>2</sub> vent connected to the reaction chamber for releasing CO<sub>2</sub> into the atmosphere, a hinged lid attached to the reaction chamber allowing insertion of waste into the anolyte portion as liquid, solid, or mixtures of liquids and solids, an anolyte pump connected to the reaction chamber, an inorganic compounds removal and treatment system connected to the anolyte pump for removing chlorides and other precipitates forming anions present in the biological and organic waste being processed, thereby precluding formation of unstable oxycompounds.

77. The apparatus of claim 76, further comprising an off-gas cleaning system, comprising scrubber/absorption columns connected to the vent, a condenser connected to the anolyte reaction chamber, whereby non-condensable incomplete oxidation products, low molecular weight organics and carbon monoxide are reduced to acceptable levels for atmospheric release by the gas cleaning system, and wherein the anolyte off-gas is contacted in the gas cleaning system wherein the noncondensibles from the condenser are introduced into the lower portion of the gas cleaning system through a flow distribution system and a small side stream of freshly oxidized anolyte direct from the electrochemical cell is introduced into the upper portion of the column, resulting in a gas phase continuously reacting with the oxidizing mediator species as it rises up the column past the down flowing anolyte, and external drain, for draining to an

cleaning gases before release into the atmosphere, and an atmospheric vent connected to the off-gas cleaning system for releasing gases into the atmosphere, wherein cleaned gas from the off-gas cleaning system is combined with unreacted components of the air introduced into the system and discharged through the atmospheric vent.

83. The apparatus of claim 81, further comprising a screwed top on the catholyte reservoir to facilitate flushing out the catholyte reservoir, a mixer connected to the catholyte reservoir for stirring the catholyte, a catholyte pump connected to the catholyte reservoir for circulating catholyte back to the electrochemical cell, a drain for draining catholyte, a flush for flushing the catholyte system, and an air sparge connected to the housing for introducing air into the catholyte reservoir, wherein the catholyte portion of the electrolyte is circulated by pump through the electrochemical cell on the cathode side of the membrane, and wherein contact of oxidizing gas with the catholyte portion of the electrolyte is enhanced by promoting gas/liquid contact by mechanical and/or ultrasonic mixing.

84. The apparatus of claim 51, wherein the electrochemical cell is operated at high membrane current densities for increasing a rate of waste and/or inorganic materials destruction, also results in increased mediator ion transport through the membrane into the catholyte, and further comprising an anolyte recovery system positioned on the catholyte side, air sparging on the catholyte side to dilute and remove off-gas and hydrogen, wherein some mediator oxidizer ions species cross the membrane and are removed through the anolyte recovery system to maintain process efficiency or cell operability.

85. The apparatus of claim 51, further comprising a controller, a microprocessor, a monitor and a keyboard connected to the cell for inputting commands to the controller through the keyboard responding to the information displayed on the monitor, a program in the controller sequencing the steps for operation of the apparatus, program having pre-programmed sequences of operations the operator follows or chooses other sequences of operations, the controller allows the operator to select sequences within limits that assure a safe and reliable operation, the controller sends digital commands that regulate electrical power to pumps, mixers, thermal controls, ultraviolet sources, ultrasonic sources, CO<sub>2</sub>

organic compound removal system and the inorganic compounds removal and treatment system, and for draining the anolyte system, wherein the organic compounds recovery system is used to recover waste and/or inorganic materials that are benign and do not need further treatment, and waste and/or inorganic materials that will be used in the form they have been reduced.

78. The apparatus of claim 76, further comprising thermal control units connected to heat or cool the anolyte to a selected temperature range when anolyte is circulated into the reaction chamber through the electrochemical cell by pump on the anode chamber side of the membrane, a flush for flushing the anolyte, and a filter located at the base of the reaction chamber to limit the size of exiting solid particles to approximately 1mm in diameter.

79. The apparatus of claim 51, wherein the direct current for the electrochemical cell is provided by a DC power supply, which is powered by an AC power supply, and wherein the DC power supply is low voltage high current supply operating at or below 10V DC and the AC power supply operates off an about 110v AC line for the smaller units and about 240v AC for larger units.

80. The apparatus of claim 51, further comprising an electrolyte containment boundary composed of materials resistant to the oxidizing electrolyte selected from a group consisting of stainless steel, PTFE, PTFE lined tubing, glass and ceramics, and combinations thereof.

81. The apparatus of claim 51, further comprising an anolyte recovery system connected to a catholyte pump, a catholyte reservoir connected to the cathode portion of the electrochemical cell, a thermal control unit connected to the catholyte reservoir for varying the temperature of the catholyte portion, a bulk of the catholyte portion being resident in a catholyte reservoir, wherein the catholyte portion of the electrolyte flows into a catholyte reservoir, and further comprising an air sparge connected to the catholyte reservoir for introducing air into the catholyte reservoir.

82. The apparatus of claim 81, further comprising an anolyte recovery system for capturing the anions and for reintroducing the anions into the anolyte chamber upon collection from the catholyte electrolyte, an off-gas cleaning system connected to the catholyte reservoir for

vents, air sparge, and the electrochemical cell, the controller receives component response and status from the components, the controller sends digital commands to the sensors to access sensor information through sensor responses, sensors in the apparatus provide digital information on the state of components, sensors measure flow rate, temperature, pH, CO<sub>2</sub> venting, degree of oxidation, and air sparging, the controller receives status information on electrical potential across the electrochemical cell or individual cells in a multi-cell configuration and between reference electrodes internal to the anolyte and catholyte chambers of the electrochemical cells and the current flowing between the electrodes within each cell.

86. A waste and/or inorganic materials destruction system, comprising a housing constructed of metal or high strength plastic surrounding an electrochemical cell, with electrolyte and a foraminous basket in the cell, an AC power supply with a power cord, a DC power supply connected to the AC power supply, the DC power supply providing direct current to the electrochemical cell, a control keyboard for input of commands and data, a monitor screen to display the systems operation and functions, an anolyte reaction chamber with a basket, status lights for displaying information about the status of the treatment of the organic waste material, an air sparge for introducing air into a catholyte reservoir below a surface of a catholyte, a CO<sub>2</sub> vent incorporated into the housing to allow for CO<sub>2</sub> release from the anolyte reaction chamber, an atmospheric vent facilitating the release of gases into the atmosphere from the catholyte reservoir, a hinged lid for opening and depositing the organic waste in the basket in the anolyte reaction chamber, a locking latch connected to the hinged lid, and in the anolyte reaction chamber an anolyte portion further comprising an aqueous acid, alkali, or neutral salt electrolyte and mediated oxidizer species solution in which an oxidizer form of a mediator redox couple initially may be present or may be generated electrochemically after introduction of the waste and application of DC power to the electrochemical cell, a controller with a control keyboard for input of commands and data, a monitor screen to display operations and functions of the systems, status lights for displaying information about status of the treatment of the waste and/or inorganic materials.



87. The system of claim 86, wherein the waste and/or inorganic materials is introduced when the anolyte is at room temperature, operating temperature or intermediate temperature, and the waste and/or inorganic materials is rapidly oxidized at temperatures below boiling point of the anolyte portion at ambient pressure, and further comprising a pump circulating the anolyte portion of the electrolyte, an in-line filter preventing solid particles large enough to clog electrochemical cell flow paths from exiting the reaction chamber, an inorganic compound removal and treatment system and drain outlets connected to the anolyte reaction chamber, whereby residue is pacified in the form of a salt and may be periodically removed, and a removable top connected to a catholyte reservoir allowing access to the reservoir for cleaning and maintenance.

88. A waste and/or inorganic materials oxidizing process, comprising an operator engaging an 'ON' button on a control keyboard, a system controller which comprises a microprocessor running a program and controlling a sequence of operations, a monitor screen displaying process steps in proper sequence, status lights on a panel providing status of the process, opening a lid and placing the waste and/or inorganic materials in a basket as a liquid, solid, or a mixture of liquids and solids, retaining a solid portion of the waste and/or inorganic materials and flowing a liquid portion through the basket and into an anolyte reaction chamber, activating a locking latch after the waste and/or inorganic materials are placed in the basket, activating pumps which begins circulating the anolyte and a catholyte, once the circulating is established throughout the system, operating mixers, once flow is established, turning on thermal control units and initiating anodic oxidizing and electrolyte heating programs, energizing an electrochemical cell to electric potential and current density determined by the program of the controller program, using programmed electrical power and electrolyte temperature ramps for maintaining a predetermined waste and/or inorganic materials destruction rate profile as a relatively constant reaction rate as more reactive waste components are oxidized, thus resulting in the remaining waste becoming less and less reactive, thereby requiring more and providing more vigorous oxidizing conditions, by activating ultrasonic and ultraviolet systems in the anolyte reaction chamber and catholyte reservoir, releasing CO<sub>2</sub> from the biological and organic materials in the waste and/or inorganic

materials oxidizing process in the anolyte reaction chamber, activating air sparge and atmospheric vent in a catholyte system, monitoring progress of the process in the controller by cell voltages and currents, monitoring CO<sub>2</sub>, CO, and O<sub>2</sub> gas composition for CO<sub>2</sub>, CO and oxygen content, decomposing the waste and/or inorganic materials into water and CO<sub>2</sub>, the latter being discharged out of the CO<sub>2</sub> vent, air sparging drawing air into a catholyte reservoir, and discharging excess air out of an atmospheric vent, determining with an oxidation sensor that desired degree of waste and/or inorganic materials destruction has been obtained, setting the system to standby, and executing system shutdown using the controller keyboard system operator.

89. The process of claim 88, further comprising placing the system in a standby mode during the day and adding waste and/or inorganic materials as it is generated throughout the day, placing the system in full activation during non-business hours, operating the system at low temperature and ambient atmospheric pressure and not generating toxic compounds during the oxidation of the waste and/or inorganic materials, making the process indoors compatible, scaling the system between units small enough for use by a single practitioner and units large enough for replacing hospital incinerators, releasing CO<sub>2</sub> oxidation product from the anolyte system out through the CO<sub>2</sub> vent, and venting-off gas products from the catholyte reservoir through the atmospheric vent.

90. The process of claim 88, further comprising introducing the waste and/or inorganic materials into a room temperature or cooler system with little or none of the mediator redox couple in the oxidizer form, depending upon reaction kinetics, heat of reaction and similar waste characteristics.